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**A METHOD FOR DETERMINING
THE INTAKE
OF VARIOUS CONTAMINANTS
THROUGH THE CONSUMPTION OF
ONTARIO SPORT FISH**

MARCH 1989

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Jim Bradley
Minister

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A METHOD FOR DETERMINING THE INTAKE
OF VARIOUS CONTAMINANTS
THROUGH THE CONSUMPTION OF ONTARIO SPORT FISH

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March 1989

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TABLE OF CONTENTS

	<u>Page</u>
Table of Contents.....	i
List of Tables.....	ii
List of Figures.....	iii
1. INTRODUCTION.....	1
a) Fish Contaminant Monitoring Program.....	1
b) About This Report.....	1
2. CALCULATION METHODS.....	2
3. EXAMPLES OF PREDICTED CONTAMINANT CONSUMPTION.....	4
a) Toxaphene Intake Through Ontario Sport Fish.....	6
b) Toxaphene Intake by Consuming Lake Trout from Kamaniskeg Lake..	6
c) Mercury Intake by Consuming Lake St. Clair Sport Fish.....	11
4. CONCLUSIONS	17
REFERENCES.....	19

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LIST OF TABLES

	<u>Page</u>
Table 1 - Toxaphene Consumption in Ontario Sport Fish.....	7
Table 2 - Total Mercury Consumption From Lake St. Clair Sport Fish.....	14

LIST OF FIGURES

	<u>Page</u>
Figure 1 - Summary of the Calculation Methods.....	5
Figure 2 - Summary of the Calculation for Toxaphene Intake by Consuming Lake Trout from Kamaniskeg Lake.....	10
Figure 3 - Mean Annual Mercury Concentrations in Lake St. Clair Walleye, 1970 - 1985.....	12
Figure 4 - % of Maximum ADI for Mercury Assuming Daily Consumption of Lake St. Clair Walleye.....	15

1. INTRODUCTION

a) Fish Contaminant Monitoring Program

The sport fish contaminant values used in the contaminant intake assessment which follows were obtained from information collected through the Fish Contaminant Monitoring Program, which is a co-ordinated effort of the Ontario Ministries of Environment, (M.O.E.), Natural Resources (M.N.R.) and Labour (M.O.L.). The fish are primarily collected by staff of the Ministry of Natural Resources. Ministry of the Environment scientists analyze the fish samples (skinless, boneless, dorsal fillets) for various organic and inorganic contaminants and assess the findings in relation to the health significance of each contaminant as provided by medical specialists in the Ontario Ministry of Labour and Health and Welfare Canada. The resulting information is published in the annually - updated "Guide to Eating Ontario Sport Fish" ("Guide")¹, which is in its 11th year of publication, and now provides consumption advice for over 1400 locations in the province. The "Guide" is distributed through Brewers' Retail and LCBO stores, as well as offices of the Ministries of Environment, Natural Resources and Northern Development and Mines. In 1987, 250,000 copies were distributed.

b) About This Report

This report discusses a method of determining the human intake of various contaminants through sport fish consumption, using results from a cross-section of Ontario anglers who responded to a questionnaire enclosed in the 1986 "Guide". Readers were asked about their angling and fish consuming habits, and the results were published in the report "A Comparison of the Results from the Guide to Eating Ontario Sport Fish Questionnaires".² The general calculations, which can be applied to any contaminant, are

explained initially. These calculations are then applied to several contaminants, using both province-wide studies and intensive investigations from specific waterbodies, to illustrate uses of this predictive method. Although any specific contaminant could be employed to illustrate this method, toxaphene and mercury were chosen because of previous study work. Toxaphene data was used as examples of both a province-wide and a specific location (Kamaniskeg Lake) sport fish consumption study. Mercury data was used in a study of Lake St. Clair sport fish consumption. This lake has been intensively studied for mercury levels in sport fish since 1970.

2. CALCULATION METHODS

In order to determine contaminant intake through sport fish consumption, it was initially necessary to determine the number of grams(g)/day of sport fish consumed by anglers. From a total of 1640 anglers who responded to the 1986 questionnaire, 1347 anglers indicated that they consumed Ontario sport fish. The questions which applied to the determination of the daily sport fish consumption figure were as follows:

8. How often did you eat fish caught by angling from Ontario waters?

☐ Daily	☐ More than once a week
☐ Once a week	☐ Once every 2 weeks
☐ Once a month	☐ Once every 4 months
☐ Once only	☐ Never
☐ Other (example: daily during 2 week vacation): _____	

9. How much fish caught by angling from Ontario waters would you eat at a single meal?

☐ Less than 2 oz. (57g)	☐ 2 oz. (57g)
☐ 4 oz. (113g)	☐ 6 oz. (170g)
☐ 8 oz. (227g)	☐ 12 oz. (340g)
☐ 1 lb. (454g)	☐ More than 1 lb. (454g)

Using the results from Question 9, the average meal size was found to be 294.3 g (10.4 oz.) (Note that for the "less than 2 oz. (57 g)" response, a value of 1 oz. (28.4 g) was used, and for the "more than 1 lb. (454 g)" response, 20 oz. (567 g) was used).

Using the results from Question 8, a figure of 30.6 meals/consumer/year was derived. (Note that for the "more than once a week" category, 2.5 times/week was used, and only those responses in the "other" category which were obvious, such as "twice/year" were used, and not such statements as "a few times/month" or "during a 2 week vacation"). When the meal frequency was multiplied by the average meal size, an annual consumption figure of 8992.9 g (317.2 oz.) was derived. For the purposes of this report, it was assumed that the fish were consumed in an equal amount each day throughout the year. This daily average was calculated as 24.7 g (0.87 oz.)/day. This consumption figure suggests that Ontario sport fish anglers consume much more fish than the consumption figures suggested by the Federal government (18 g/day)¹⁰ and several United States agencies (6.2 g/day, 6.5 g/day and 16 g/day).^{12, 13, 14}

Once the daily sport fish consumption figure was determined, it was next necessary to determine the relative consumption of each fish species. For this calculation, the total weight of fish consumed had to be determined using the number eaten multiplied by the mean weight. Here it was necessary to have good creel census information on the area or waterbody being studied. Information on the number of fish eaten by species was provided by an in-depth province-wide survey done by the Ministry of Natural Resources entitled "1980 Survey of Ontario's Resident and Non-Resident Sport Fishermen"³ (only identified fish species were used, ie. "total coarse fish", "total panfish" etc. were not included).

The mean weight for each species was determined from the weights of the fish sampled for the particular contaminant. These mean weights were then multiplied by the number eaten,

to determine the total weight of each species consumed. When these total weights by species were divided by the total weight of all the species consumed, the percentages by species of the total fish eaten were obtained. These percentages were then applied to the daily sport fish consumption rate of 24.7 g, giving the number of grams of each fish species which would be consumed. This would then apply on a province-wide basis to what a typical Ontario angler would be likely to consume. This method can also be applied to a specific waterbody, using just the species found in the waterbody (see section 3(c) Lake St. Clair).

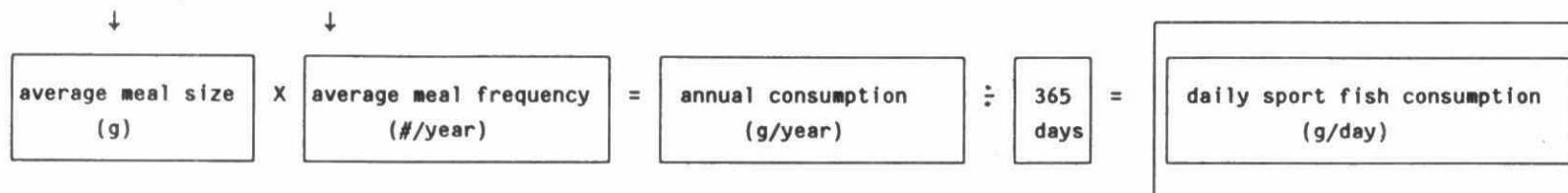
The total consumption of the particular contaminant (ie. toxaphene or mercury) was derived from the number of grams of each species eaten multiplied by the mean contaminant concentrations (obtained from all the M.O.E./M.N.R. sport fish contaminant results). When these values were totalled for all species in the particular study area, the total consumption value was then compared to the Acceptable Daily Intake (ADI) for toxaphene as determined by Health and Welfare Canada⁴ (using a 70 kg human as a standard) to indicate if the calculated amount of toxaphene consumed was within the proposed limits for consumption. Mercury consumption was compared to the World Health Organization's recommended daily total consumption of total mercury. For a summary of the method used in the above calculations, see Figure 1.

3. EXAMPLES OF PREDICTED CONTAMINANT CONSUMPTION

In the following section, three sets of example calculations are employed to illustrate different possible applications of this predictive method. The first example is a province-wide estimate of toxaphene intake by anglers consuming Ontario sport fish. The second example is an estimate of contaminant intake using a particular species for a specific waterbody.

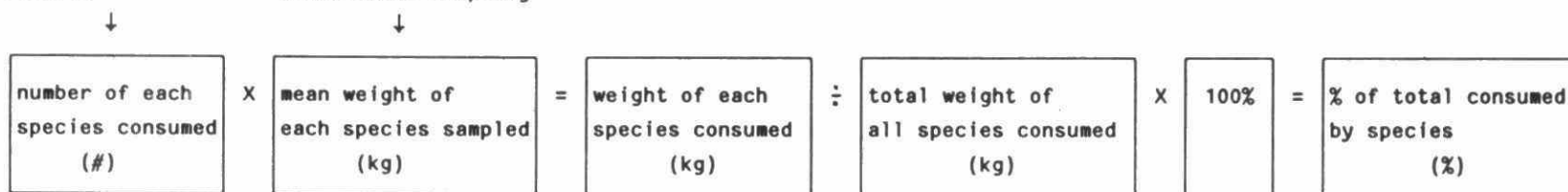
FIGURE 1. SUMMARY OF THE CALCULATION METHODS

1986 "Guide" questionnaire

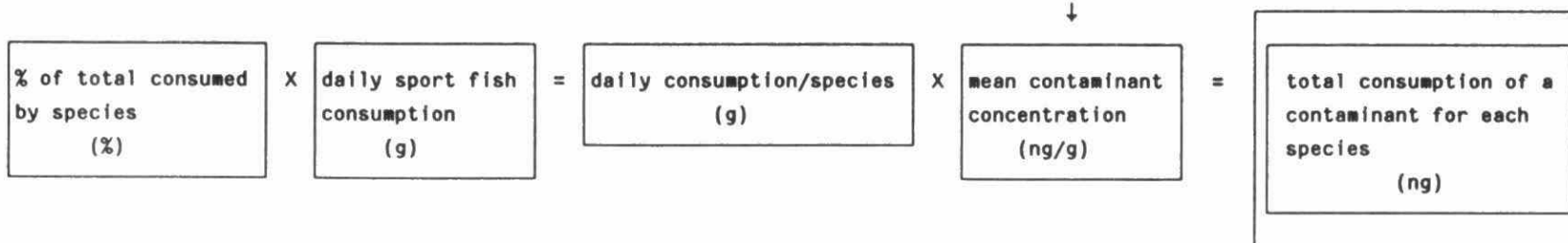


M.N.R. 1980 survey results

M.N.R. sport fish contaminant sampling



M.O.E./M.N.R. sport fish contaminant analysis



Using the results from Question 9, the average meal size was

In this case, toxaphene intake using lake trout from Kamaniskeg Lake was calculated. The third example predicts mercury intake from the consumption of Lake St. Clair sport fish to illustrate how a specific waterbody can be studied for the intake of contaminants through a variety of available sport fish species.

a) Toxaphene Intake Through Ontario Sport Fish

An estimation of the toxaphene intake by anglers consuming Ontario sport fish was calculated on a province-wide basis. Table 1 shows the data used to derive the total toxaphene consumption. The mean weights of fish were derived from the weights of the fish sampled for toxaphene. The exceptions were muskie and crappie, which had not been sampled for toxaphene. These values were estimated from the best available information.⁵

The overall toxaphene consumption figure was 2408 ng/day or 2.41 ug/day. The ADI for toxaphene is .0002 mg/kg body weight/day, based on Health and Welfare Canada's tentative No Observed Effect Limit of 0.2 mg/kg divided by a 1000 fold safety factor.⁴ Using a 70 kg human as a standard, this would be .014 mg or 14 ug of toxaphene. The calculated value of 2.41 ug was only 17.2% of this ADI, indicating that the intake of toxaphene through sport fish consumption in Ontario was well within Health and Welfare Canada's proposed limits for toxaphene consumption.

b) Toxaphene Intake by Consuming Lake Trout from Kamaniskeg Lake

Toxaphene levels in the larger lake trout in Kamaniskeg Lake were the highest mean levels detected in all the M.O.E./M.N.R. sport fish toxaphene analyses. Therefore, this lake was studied as an example of contaminant intake using a particular species for a specific waterbody. The toxaphene intake in this example was a

TABLE 1 - TOXAPHENE CONSUMPTION IN ONTARIO SPORT FISH

Species	# eaten (X 10 ³)	mean weight (kg)	total weight (kg) (X 10 ³)	% of total fish eaten	#g eaten (out of 24.7 g/day)	mean toxaphene (ppb)	total toxaphene consumption (ng)
Largemouth Bass	1952	0.55	1073.6	3.17	0.78	0.5	0.39
Smallmouth Bass	3963	0.64	2536.3	7.50	1.85	38.9	71.97
Bullhead	938	0.38	356.4	1.05	0.26	3.8	0.99
Burbot	987	1.24	1223.9	3.62	0.89	5.1	4.54
Carp	62	4.26	264.1	0.78	0.19	327.6	62.24
Catfish	1219	1.13	1377.5	4.07	1.00	323.9	323.90
Chub(Bloater)	40	0.18	7.2	0.02	0.005	370.4	1.85
Crappie	549	0.23	126.3	0.37	0.09	2.6 ¹	0.23
Herring	300	0.46	138.0	0.41	0.10	171.0	17.10
Muskie	78	5.44	424.3	1.25	0.31	25.5 ²	7.91
Northern Pike	2577	1.57	4045.9	11.96	2.95	25.5	75.23
Yellow Perch	16575	0.17	2817.8	8.33	2.05	26.1	53.51
Pumkinseed	403	0.15	60.5	0.18	0.04	0.5	0.02
Rock Bass	835	0.13	108.6	0.32	0.08	4.6	0.37
Chinook	31	5.61	173.9	0.51	0.13	515.9	67.07
Coho	141	2.80	394.8	1.17	0.29	192.7	55.88
Sheepshead	45	0.62	27.9	0.08	0.02	85.0	1.70
Smelt	22968	0.09	2067.1	6.11	1.51	236.8	357.57
Suckers	161	0.87	140.1	0.41	0.10	14.8	1.48
Brook Trout	2270	0.45	1021.5	3.02	0.74	38.3	28.34
Brown Trout	125	2.04	255.0	0.75	0.18	262.4	47.23
Lake Trout	1049	2.02	2119.0	6.26	1.54	365.6	563.02
Rainbow Trout	1022	2.40	2452.8	7.25	1.79	211.9	379.30
Splake	218	0.45	98.1	0.29	0.07	87.0	6.09
Walleye	8477	1.18	10002.9	29.60	7.30	34.5	251.85
White Bass	151	0.29	43.8	0.13	0.03	31.0	0.93
Whitefish	389	1.24	482.4	1.43	0.35	77.9	27.27
TOTALS			33839.7	100.04	24.65		2407.98

¹ Mean toxaphene value derived from means of Rock Bass and Pumpkinseed values² Mean toxaphene value for Northern Pike used for Muskie value

most extreme case in which people consume only lake trout from Kamaniskeg Lake and no other sport fish species.

There are two sets of calculations employed in this example. In the first set, the daily toxaphene consumption was calculated and the results were compared to the ADI for toxaphene. In the second set, the total edible mass of lake trout was determined, and this was employed in calculating the possible number of people who could be consuming these fish daily.

Kamaniskeg Lake is a 2900 hectare lake located just southeast of Algonquin Provincial Park. In order to determine the number of lake trout caught in the lake, 1976-1983 creel survey information from the Ministry of Natural Resources⁶ was used, yielding a mean catch of 178/year, with a mean weight of 1.21 kg. Therefore the total weight of lake trout caught/year averaged 215.4 kg. When the 970 ppb mean toxaphene value for these trout was combined with the previously determined daily sport fish consumption of 24.7 g/day, the resulting daily toxaphene consumption was 23.9 ug/day. This value was 1.7 times the ADI of 14 ug for a 70 kg human. However, it should be noted that the mean toxaphene value was based on sampled lake trout with a mean weight of 6 kg, which was much heavier than the fish being consumed based on the creel census information. Given that toxaphene residue levels increase with the size (age) of fish, this calculation represented the highest possible consumption rate.

Since only one species was used in the calculations, the total edible mass of lake trout was determined. The amount of edible flesh obtained from a whole fish ranges from 30-40% of the total weight, depending on the skill of the filleter. These values have been determined by Fisheries and Oceans Canada in their fish handling and preparation guide.⁷ For the purposes of this report, approximate total edible mass factors of both 0.3 and 0.4 of the

whole fish were used in the calculations. If the 0.4 factor was applied to the total weight of whole lake trout caught/year (215.4 kg), then there would be 86.2 kg of edible mass of lake trout available for consumption. If the 0.3 factor was applied, there would be 64.6 kg of edible mass available.

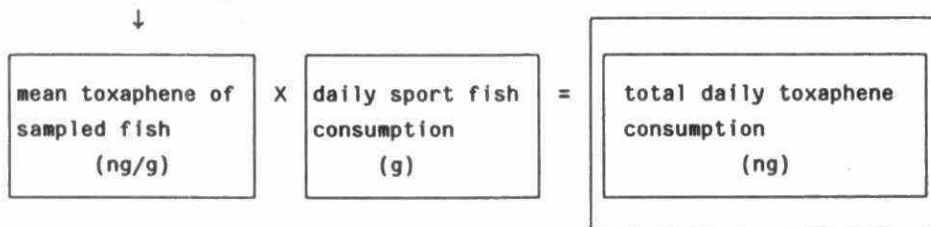
Another factor which must be applied to the calculations is the fishing season length, which for lake trout on Kamaniskeg Lake is 283 days (January 1 - October 10)⁸. This season length factor assumes that the legal one day possession limit of three lake trout would prevent daily consumption for 365 days/year. (It should be noted that people who illegally store more than one day's limit of these lake trout for further consumption will be intaking more toxaphene than the calculated values). In order to determine the approximate number of people who could possibly consume lake trout daily from Kamaniskeg Lake, it was necessary to apply this season length value to the calculated daily sport fish consumption figure of 24.7 g. Therefore, during the fishing season, 7.0 kg (24.7 g X 283) of lake trout could be consumed/person. When this is applied to the 0.4 total edible mass factor result of 86.2 kg of edible lake trout, approximately 12 people could consume these fish daily during the fishing season. Using the same calculations with the 0.3 factor, this would be approximately nine people. (Actual creel survey information (1976-1983) indicated that an average of 45 people angled for lake trout on Kamaniskeg Lake. Assuming an equitable distribution of the catch, each angler could be consuming approximately 1.96 kg of lake trout flesh during the fishing season. This would equate to receiving approximately 49% of the maximum ADI for toxaphene during the 283 day fishing season). For a summary of the methods used for these calculations, see Figure 2.

Therefore the daily toxaphene consumption levels for people consuming lake trout from Kamaniskeg Lake would be close to or below the ADI levels for two reasons. First, as previously

FIGURE 2. SUMMARY OF THE CALCULATIONS FOR TOXAPHENE INTAKE BY CONSUMING LAKE TROUT FROM KAMANISKEG LAKE

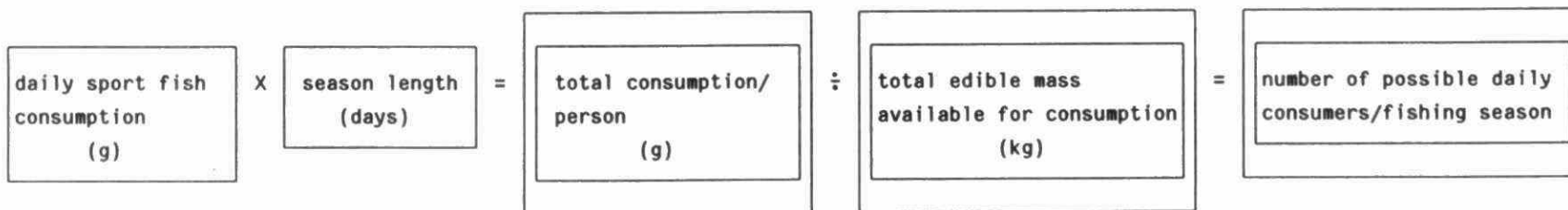
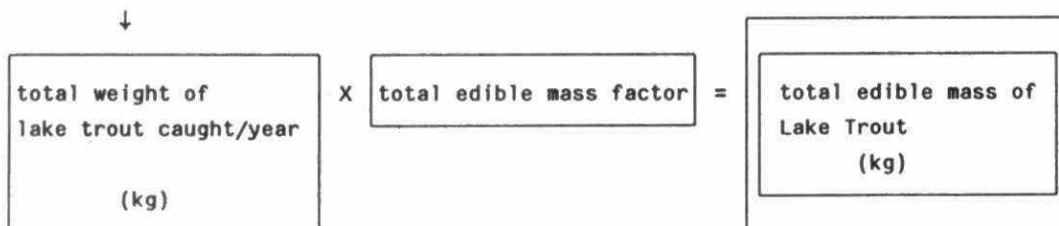
a) Total Daily Consumption

M.O.E/M.N.R. sport fish
contaminant analyses



b) Total Possible Consumption and Consumers

M.N.R. creel survey
information

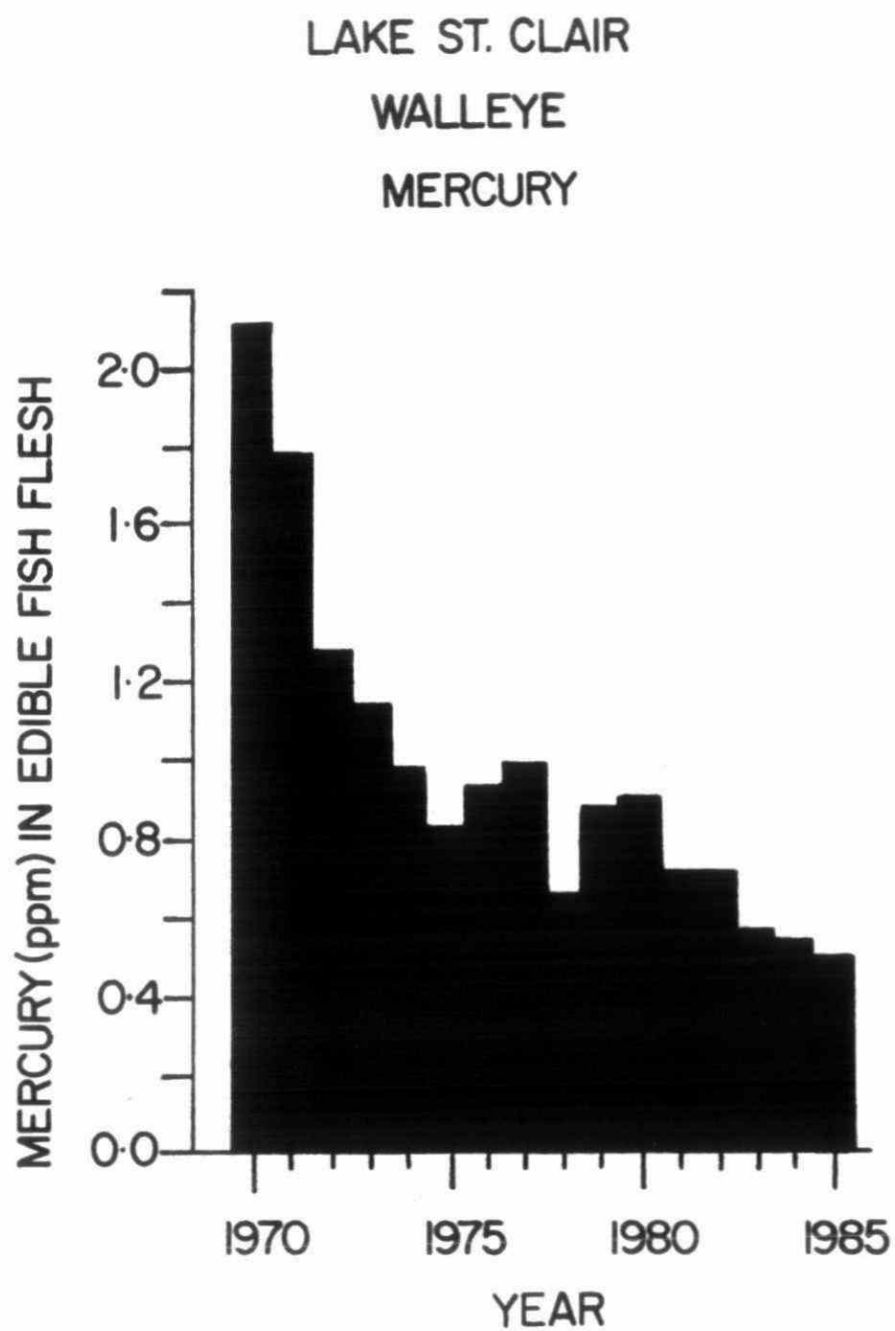


mentioned, the fish being consumed were smaller than the sampled fish which had high toxaphene levels. As well, it would be necessary to consume these lake trout daily for 283 days/year, and this extreme case was calculated as possible for approximately nine to twelve people. Therefore it is probable that, even in the extreme case of Kamaniskeg Lake, sport fish toxaphene consumption in Ontario is within the tentative limits set by Health and Welfare Canada for toxaphene consumption.

c) Mercury Intake by Consuming Lake St. Clair Sport Fish

This example calculation uses mercury in Lake St. Clair sport fish, and shows how a specific waterbody can be studied for the intake of contaminants through the variety of available sport fish species. When a specific waterbody is studied, there are usually one or two species which are sought and preferred for consumption, so that there is a need for good local creel survey information. For Lake St. Clair, on-going creel information is provided by the Lake St. Clair Fisheries Assessment Unit of the Ministry of Natural Resources.⁹ This creel information showed that walleye is the sport fish species which is the most sought and preferred for consumption. Both summer and winter creel surveys are taken to determine the number of fish caught and kept, and for these example calculations, the summer survey results for 1985 were used, as this was the peak fishing period. Since the discovery of mercury contamination in Lake St. Clair fish in 1970, this lake has been intensively studied for sport fish contaminants by the Ministry of the Environment. Steady declines in mercury concentrations have been noted for species monitored throughout this period. Figure 3 shows these declines using the mean annual concentrations in the edible flesh of walleye.

FIGURE 3. MEAN ANNUAL MERCURY CONCENTRATIONS IN LAKE ST. CLAIR WALLEYE, 1970-1985.



Two example consumption calculations are shown, with both the mean and the maximum detected mercury levels for each species being used. The mean mercury level calculations would represent the typical total mercury consumption. The maximum mercury level calculations would show the maximum total mercury consumption if only the larger fish of each species were consumed. The mercury concentrations used were from the most recently available Ministry of the Environment results (1985 for most species).

Table 2 shows the data used to derive the total mercury consumption using both the mean and maximum values. The percent of the total fish eaten was derived from the harvest numbers in the 1985 Ministry of Natural Resources creel survey. Walleye was the dominant species, representing 58% of the sport fish kept for consumption. The daily mean mercury consumption through sport fish was 10.7 ug, which was well within the World Health Organization's recommended daily total consumption of 35 ug of total mercury.¹⁰ Using the maximum mercury concentrations, the daily mercury consumption would be 34.9 ug, which is at the maximum recommended level for total mercury consumption from all sources.

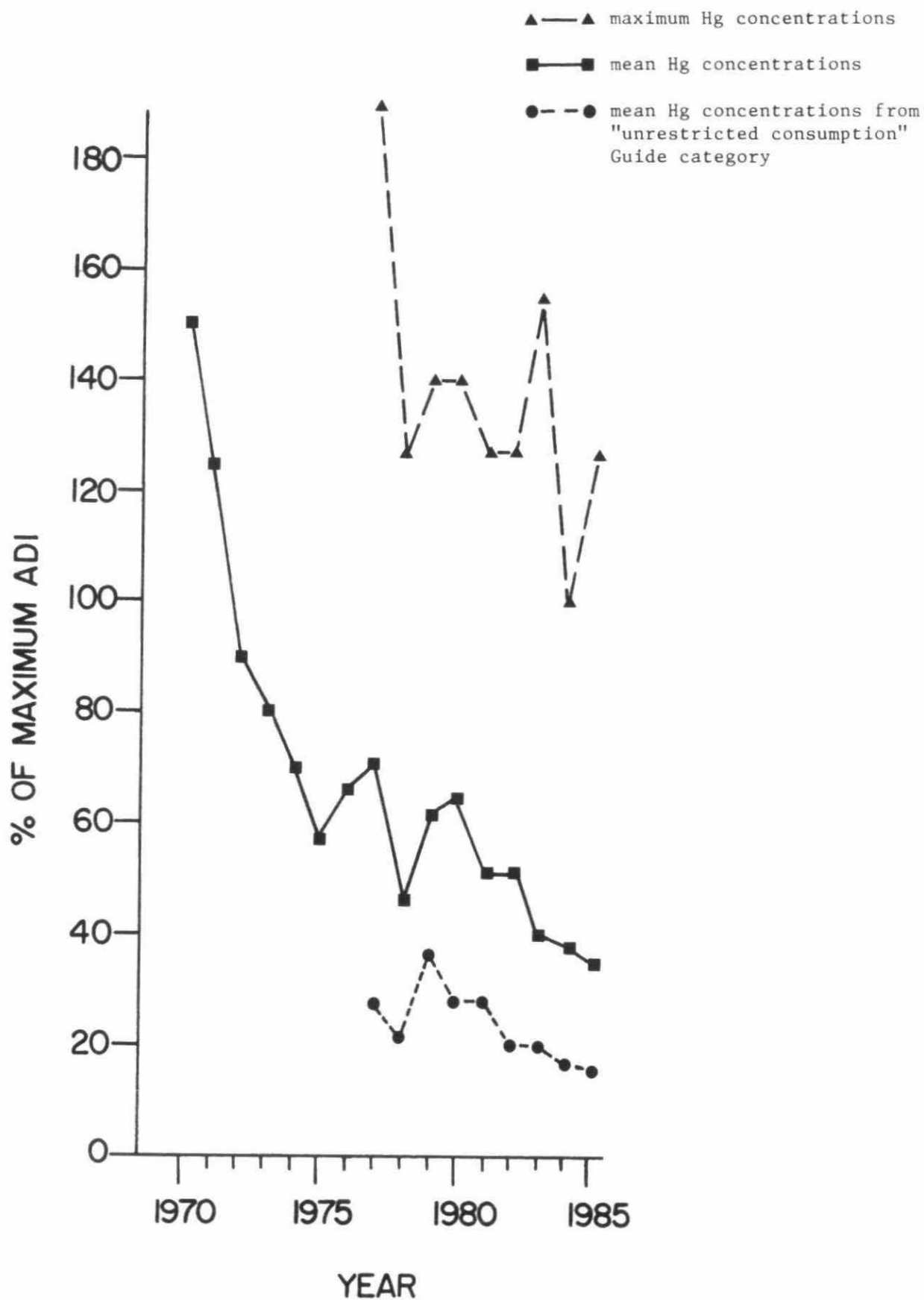
Figure 4 shows the percentage of the maximum ADI for mercury which would be consumed if the daily sport fish consumption was based only on walleye. This figure shows three projections, the first being the percentage of the maximum ADI using the maximum annual mercury concentrations from 1970 - 1985. These concentrations would represent what an angler would ingest if consuming all larger size walleye, without following the recommendations in the "Guide." This pattern of consumption would result in mercury intake at or above the maximum ADI level from sport fish alone, excluding other sources of mercury intake.

TABLE 2. TOTAL MERCURY (Hg) CONSUMPTION FROM LAKE ST. CLAIR SPORT FISH

Species	% of total eaten	# of grams eaten (out of 24.66)	mean Hg (ppm)	maximum Hg (ppm)	Total Hg consumption	
					mean (ug/day)	maximum (ug/day)
Walleye	58.0	14.30	.49	1.80	7.01	25.74
Yellow Perch	19.1	4.71	.22	.68	1.04	3.20
Smallmouth Bass	8.6	2.12	.41	.79	0.87	1.67
Freshwater Drum	3.1	0.76	.59	1.90	0.45	1.44
Rock Bass	2.9	0.72	.52	.96	0.37	0.69
White Perch	2.8	0.69	.25	.48	0.17	0.33
White Bass	1.2	0.30	.31	.78	0.09	0.23
Channel Catfish	1.2	0.30	.23	.44	0.07	0.13
Black Crappie	0.7	0.17	.58	1.38	0.10	0.23
Pumpkinseed	0.6	0.15	.46	.83	0.07	0.12
Bluegill	0.5	0.12	.74	.88	0.09	0.11
Largemouth Bass	0.4	0.10	.77	1.40	0.08	0.14
Muskie	0.4	0.10	2.67	7.11	0.27	0.71
Northern Pike	0.3	0.07	.59	1.00	0.04	0.07
Redhorse Sucker	0.08	0.02	.42	1.05	0.01	0.02
White Sucker	0.06	0.02	.29	1.20	0.01	0.02
Mooneye	0.02	0.005	-*	-	-	-
Bowfin	0.02	0.005	-*	-	-	-
Longnosed Gar	0.01	0.002	-*	-	-	-
TOTALS	99.99	24.662			10.74	34.85

* No mercury values were available for these species, however, they only constituted 0.05% of the total fish eaten.

FIGURE 4. % OF THE MAXIMUM ADI FOR MERCURY(Hg) ASSUMING DAILY CONSUMPTION OF
LAKE ST. CLAIR WALLEYE



The second projection shows the percentage of the maximum ADI using the mean annual mercury concentrations from Figure 3. These concentrations would represent what the intake would be if again the recommendations from the "Guide" were not followed and all edible size walleye were consumed. In 1970, the daily consumption of these walleye would have been 149% of the maximum ADI, and with the declining mean levels, the percentage dropped to 35% by 1985.

As a further comparison, beginning in 1977 with the first "Guide", the mean annual concentrations of mercury in walleye from only the "unrestricted consumption" category were determined and were also plotted as a percentage of the maximum ADI. Figure 4 clearly shows that these values were only about half of the percentage of ADI for anglers consuming any edible size walleye. In 1985, consumption in this "unrestricted consumption" category represented only 16% of the maximum ADI for mercury. Even people who consume fish as a major protein source in their diet (117 grams/day)¹¹ would only ingest 76% of the maximum ADI if consumption was from the "unrestricted consumption" category only.

Therefore, these three projections demonstrate that if sport fish consumers follow the consumption recommendations in the "Guide to Eating Ontario Sport Fish," their mercury consumption through sport fish should remain well within the World Health Organization's maximum ADI for mercury.

4. CONCLUSIONS

1. The MOE/MNR sport fish contaminant data base is sufficient, when applied with additional information such as creel census results, to permit the calculation of contaminant intake levels to anglers through sport fish consumption. The possible applications of these calculations are: on a province-wide basis, for a typical angler; for specific waterbodies; for specific fish species; or, for subsistence anglers who might be ingesting contaminants at a level higher than the level ingested by a typical angler.
2. In order to limit the intake of contaminants found in sport fish, anglers are advised to follow both the consumption guidelines in the "Guide to Eating Ontario Sport Fish" and the MNR legal daily possession limits.
3. The use of questionnaires has proven to be a very valuable means for determining sport fish consumption information. Meal size, frequency of sport fish consumption, preferred species and preferred angling locations all contribute to improved fish consumption advice, and focus annual testing programs to those waterbodies and fish species of greatest importance.
4. The questionnaire results suggest that Ontario sport fish anglers consume much more fish (24.7 g/day) than the consumption figures suggested by the Federal government (18 g/day) and several United States agencies (6.2 g/day, 6.5 g/day and 16 g/day).
5. Long-term trend data has generally indicated declining contaminant levels in Ontario sport fish from areas seriously contaminated by past industrial activities (e.g. mercury in walleye from Lake St. Clair). Therefore, up-to-date contaminant residue results must be used in the calculation of the intake rates for an accurate indication of current potential health effects.

6. In areas where contaminant concentrations in sport fish species are rapidly changing, annual or at least bi-annual sampling of all the important angling and commercial species should be carried out.
7. For several years, the Sport Fish Testing Program has shown declining concentrations of substances such as PCB and mercury in fish from areas that were, in the past, highly contaminated. Similarly, results from the calculation procedures presented in this report clearly show that human ingestion of contaminants in sport fish from such areas has also substantially declined.
8. Based on the tentative ADI limits set by Health and Welfare Canada for toxaphene consumption, toxaphene is not a contaminant of concern to sport fish consumers in Ontario. In the worst case example of Kamaniskeg Lake, daily consumption of lake trout would equate to receiving approximately 49% of the maximum ADI for toxaphene during the fishing season (assuming an equitable distribution of the lake trout catch among all anglers noted in the creel census information).
9. Anglers consuming a variety of sport fish from Lake St. Clair would not exceed the World Health Organization's recommended maximum daily mercury intake, if they follow the consumption guidelines in the "Guide", and observe the MNR legal daily possession limits.
10. Calculations based on the consumption of walleye (which was the most sought and consumed sport fish species for Lake St. Clair) indicated that those anglers who followed the "Guide" consumption guidelines would be consuming mercury at levels well within the World Health Organization's maximum ADI for mercury. Those anglers who chose to ignore the "Guide" consumption advice and eat only large walleye from Lake St. Clair would be putting themselves at risk, by exceeding the maximum ADI for total mercury.

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